DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF

NEDPL-PS

RECONNAISSANCE REPORT

LOCAL FLOOD PROTECTION

PAWTUXET RIVER

WARWICK, RHODE ISLAND

JULY 1983

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I. AUTHORIZATION

Reconnaissance scope studies have been accomplished under authority contained in Section 205 of the 1948 Flood Control Act, as amended to determine the need and feasibility of reducing flood damages to the General Electric (GE) facility in Warwick, Rhode Island. Federal assistance was requested on 3 March 1983 by Barbara Sokoloff, Director, Warwick Department of City Plan.

The Corps of Engineers has the authority to construct certain small flood control projects under Section 205. The Federal cost is limited to $4 million on each project, which includes all related costs for investigations, inspections, engineering, preparation of plans and specifications, supervision, administration, and construction. A project is adopted under Section 205 only after detailed investigation clearly shows that the proposed project is engineeringly feasible and economically justified.

Our investigation has determined that a feasible and economical flood control alternative exists, namely floodproofing. However, the scope of the project, estimated first cost of $30,000, is such that Federal participation is not warranted.

Technical assistance can be provided GE under authority contained in Section 206 of the 1960 Flood Control Act (Public Law 86-645) which states:

> ". . .The Secretary of the Army through the Chief of Engineers, Department of the Army, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by flood of various magnitudes and frequencies, and general criteria for guidance in the use of flood plain areas and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard. . . ."

II. SCOPE OF STUDIES

The purpose of this report is to assist GE with basic information on the magnitude and frequency of flooding along the Pawtuxet River and to provide preliminary cost estimates of measures which they could implement to reduce the risk of future flood damages. Our reconnaissance scope investigation included a damage survey which helped determine the severity of the flood problem at GE.

III. PRIOR REPORTS

Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Study

This investigation was authorized under Congressional resolutions in 1968. During this study the Corps of Engineers evaluated numerous plans for flood control and allied purposes at various problem areas along the Pawtuxet River, including the GE facility which was owned by the Bulova Watch Company at that time. Plans included diversion tunnel, levees and floodwalls, flood control storage at the proposed Big River Reservoir, and nonstructural measures to reduce flood damage. However, only the Big River Reservoir and Belmont Park projects have progressed beyond this initial investigation, other basin wide solutions did not receive strong public support and were eliminated from further consideration.

Flood Insurance Study

The Federal Insurance Administration engaged the Corps of Engineers to perform a Flood Insurance Study in the city of Warwick, which was completed in 1976. The results of this study were used to develop a rate map, which identifies the various flood hazard zones in Warwick. After review of the rate map by the city, they joined the regular phase of the flood insurance program in June 1976. The rate map was updated in 1977 and 1981 to reflect existing conditions.

Warwick (Belmont Park), Rhode Island Detailed Project Report

This report was completed by the Corps of Engineers in June 1982 and contained the recommendation that 59 flood prone homes in the Belmont Park area be acquired, 17 others floodproofed, and a flood forecasting system be installed in the city of Warwick. The flood warning system was designed to provide local officials with timely and accurate forecasts of expected flood stages along the Pawtuxet River. When installed, local officials will be able to warn property owners, including GE, of the impending danger so that they can take emergency measures to reduce losses and evacuate the area. The report was approved in July 1982 and the project is scheduled to be completed by 1986.

IV. DESCRIPTION OF AREA

The city of Warwick is located in Kent County on the westerly side of Narragansett Bay in central Rhode Island, approximately 10 miles south of Providence. The city has a land area of about 33 square miles. Its population of approximately 87,123 (1980 Census) makes it the second most populous city in Rhode Island.

The Pawtuxet River is the major stream that flows through the city of Warwick. Its watershed (see Plate 1) lies entirely within the State of Rhode Island and covers a total area of 230 square miles. The Pawtuxet River consists of two tributary branches which merge to form a 10.9-mile long mainstem. The North Branch rises in the hilly uplands of Foster and Gloucester near the Connecticut border and flows in generally southeasterly direction through Providence and Kent Counties toward Narragansett Bay. The South Branch originates in the slightly lower uplands of Coventry, West Greenwich, and Exeter in Kent County, and flows easterly to West Warwick where it merges with the North Branch to form the mainstem of the Pawtuxet River. The mainstem flows in a northeasterly direction through West Warwick, Warwick, and Cranston before it discharges into Narragansett Bay at Pawtuxet Cove. The main river averages about 100 feet in width and 4 feet in depth and has a total fall of about 50 feet. Approximately 3 miles of the lower reach of the mainstem was tidal estuary, however, in 1870 the Pawtuxet Dam was constructed near the mouth of the river to prevent salt water intrusion.

Three Ponds Brook is a tributary of the Pawtuxet River, with a total drainage area of 1,200 acres. The brook is about 2.3 miles in length and has an average slope of 16 feet per mile.

The GE facility is located in Warwick along the west bank of Three Ponds Brook just upstream from its confluence with the Pawtuxet River (see Plate 2). Three Ponds Brook flows through a series of six ponds before reaching the GE plant. The channel passes under the approach ramp to the plant in a 42-inch concrete pipe. It then flows east and north around the plant in a trapezoidal channel with about a 3-foot bottom, 1 on 2 slope sides, and a depth varying from 2 to 4 feet. About 1,500 feet beyond the plant the brook discharges to a former reach of the Pawtuxet River that was severed from the main river by the construction of Interstate 95. This highway was constructed around 1962 and included the relocation of about 1,500 feet of the Pawtuxet River to the west side of the highway. The severed reach of the river, including the flows of Three Ponds Brook are drained beneath Route 95 to the main river in an 8-foot by 7-foot culvert.

General Electric purchased the facility in August 1980 from the Bulova Watch Company. They employ about 250 people, which represents about 1 percent of the jobs available in the city of Warwick, with an annual payroll totalling $1.5 million. The plant is in the flood plain of the Pawtuxet River and has been flooded twice in the last three years. Protection of the GE facility is important to the city of Warwick and surrounding communities.

V. FLOOD HISTORY

In June 1982 the Pawtuxet River experienced a stage of 24.1 feet NGVD[1] at the mouth of Three Ponds Brook. The flood elevation at the General Electric plant during the same event was 24.4 feet NGVD. Based on these relative elevations, inspection of the area, and discussion with the plant engineer it was concluded that flooding is caused by backwater from the mainstem of the Pawtuxet River rather than excessive flows on Three Ponds Brook.

The flood history of the Pawtuxet River reveals that major floods can occur during any season of the year as a result of intense rainfall alone or in combination with snowmelt. The Flat River and Scituate Reservoirs control over 66 percent of the Pawtuxet watershed and have a significant modifying effect on flood development. The magnitude of floods on the Pawtuxet River are a function of a storm rainfall and the resulting runoff from the 80.9 square miles of watershed downstream of the reservoirs, and the initial storage capacity in the reservoirs.

Since 1940, the U.S. Geological Survey has maintained a stream gaging station on the Pawtuxet River in Cranston, about a mile downstream of the GE facility. The drainage area at the gage is 200 square miles. Historic flood flows at the Cranston gage are listed in Table 1.

TABLE 1

HISTORIC FLOODS

MAINSTEM PAWTUXET RIVER

Date	Discharge at Cranston, RI (cfs)
February 1886	14,000 * **
July 1938	6,300 *
March 1936	5,300 *
June 1982	5,000
January 1979	4,000
March 1968	3,110
January 1978	3,040

* estimated (Cranston gage was not in existence)
** Scituate Reservoir not in existence

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1 NGVD (National Geodetic Vertical Datum) is defined as the mean sea level of 1929

VI. FLOOD DAMAGES

Since purchasing the facility in August 1980, GE has been flooded twice. The most severe event occurred during June 1982 when water backed-up from the Pawtuxet River and inundated the lower floor of GE. Damages were estimated in excess of $600,000 and the plant was forced to shut-down operations for about 2 weeks. During April 1983 flood water again backed-up from the Pawtuxet River and inundated the lower floor of GE. Damages were not as extensive as in June 1982 because GE personnel have adopted a flood emergency program and moved damageable items above expected flood stages. However, losses were still significant and the normal operation of the plant was interrupted.

A detailed damage survey was undertaken in May 1983. The plant engineer provided a tour and an explanation of flood damage incurred during the June 1982 event. The elevation at which flood damage begins was estimated to be 22.5 feet NGVD, which is the elevation of the loading ramp where overland flow first enters the building. After an onsite inspection, dollar value estimates were made for physical damage to grounds, structures, machinery, and inventory. In addition, estimates of non-physical losses were made to include emergency costs and the effects of flooding on normal plant operations. Damage estimates were made in 1-foot increments and referenced to the June 1982 flood.

Recurring losses are those potential flood damages that are expected to occur at various elevations under present day development. The dollar values of recurring losses for a range of potential flood events are shown in the following table.

TABLE 2

RECURRING LOSSES

Frequency (years)	Approximate Elevation (feet NGVD)	Losses (dollars)
20	22	$ 1,000
50	24	700,000
100	26	1,200,000
500	29	1,300,000

The June 1982 event was estimated to be slightly greater than the 50-year event and losses associated with its recurrence are approximately $750,000.

Stage damage information obtained by field survey was combined with hydrologic stage-frequency data (see Plate 3) to provide damage frequency correlations. Expected average annual losses to the General Electric plant are approximately $29,000.

VII. PROPOSED PLANS OF PROTECTION

As mentioned earlier in this report, several basin wide plans involving the construction of reservoirs or diversion tunnels were evaluated during the PNB study. However, only two plans have progressed beyond this initial study, flood control storage at the proposed Big River Reservoir and the Belmont Park flood damage reduction project. Of these two proposed projects, only construction of the Big River Reservoir would reduce flood stages at the GE facility (approximately 1-foot during the 100-year event).

Alternatives investigated during our recent reconnaissance study are:

1. Levee
2. Floodproofing
3. No Action

1. Levee - In 1974, as part of the PNB study, it was estimated that the construction of 950 feet of levee along the west bank of Three Ponds Brook (see Plate 4) to protect the GE facility would cost $700,000. Updating this figure to a 1983 price level results in an estimated first cost of $1.2 million. The proposed levee would have an average height of 12 feet and would protect to elevation 35 feet NGVD, with 3 feet of freeboard. This project would provide the GE facility with well over 100-year protection. The annual cost to operate and maintain the project after construction was estimated at $1,000. The annual benefits of this plan equal $29,000 and are not sufficient to justify the construction of a levee.

2. Floodproofing - A visual inspection of the GE plant was performed to determine its general condition, size, and the number of door and window openings. It was determined that the most economical way to floodproof the GE facility would be to construct stoplog structures across all door openings and the entrance to the loading dock (see photos on Plate 5). During flood emergencies wooden stoplogs would be installed to close off all openings. Sand bags would be placed between stoplogs to help reduce seepage. Interior sump pumps would be installed to handle seepage. Typical plans and sections of floodproofing measures are shown on Plates 6, 7 and 8.

Floodproofing measures would provide the GE facility with protection up to elevation 26.75 feet NGVD, which is about a foot higher than the 100-year event. This plan would not prevent damages to utilities nor eliminate the need to evacuate employees and shut-down operations until floodwaters recede. It would reduce clean-up time and allow GE to return to normal operation sooner.

The cost to floodproof the GE facility was estimated at $30,000 (see Table 3). Benefits attributed to floodproofing equal $16,000 annually and are sufficient to justify this alternative. Annual operation and maintenance costs of floodproofing measures are estimated at $250. All procedures and equipment should be checked periodically by means of "dry-run" excercises to ensure that all equipment is kept available and operational and that personnel are familiar with emergency procedures.

TABLE 3

COST ESTIMATE, FLOODPROOFING

Item	No. Units	Unit Measure	Per Unit	Cost
Concrete	56	CY	$ 150.00	$ 8,400
Excavation	41	CY	7.00	287
Waterstops	124	LF	3.00	372
Stoplogs (Material Only)	2,118	BF	.80	1,695
Sand bags (Material Only)	695	Each	.25	174
Aluminum Channel & Cover	262	LF	12.00	3,144
Sump Pump	6	Each	700.00	4,200
Concrete Cutting	124	LF	10.00	1,240
Sand (Material Only)	15	CY	20.00	300
			SUBTOTAL	$ 19,812
			Contingencies 25%	4,953
				$ 24,765
			Engineering & Design	3,000
			Supervision & Administration	2,235
			TOTAL	$ 30,000

3. No Action - Under this alternative the GE facility will continue to experience periodic flooding. Representatives from GE have indicated that this alternative is unacceptable and that something must be done to reduce the risk of future flood damages.

VII. ECONOMIC JUSTIFICATION

The following table presents a summary of estimated first costs, annual costs, annual benefits, and benefit-to-cost ratios for the various alternatives just described:

TABLE 4

ECONOMIC EVALUATION

Alternative Plan	First Cost	Annual Cost	Annual Benefits	B/C Ratio
Levee	$1,200,000	$97,000	$29,000	0.3 to 1.0
Floodproofing	30,000	3,000	16,000	5.0 to 1.0

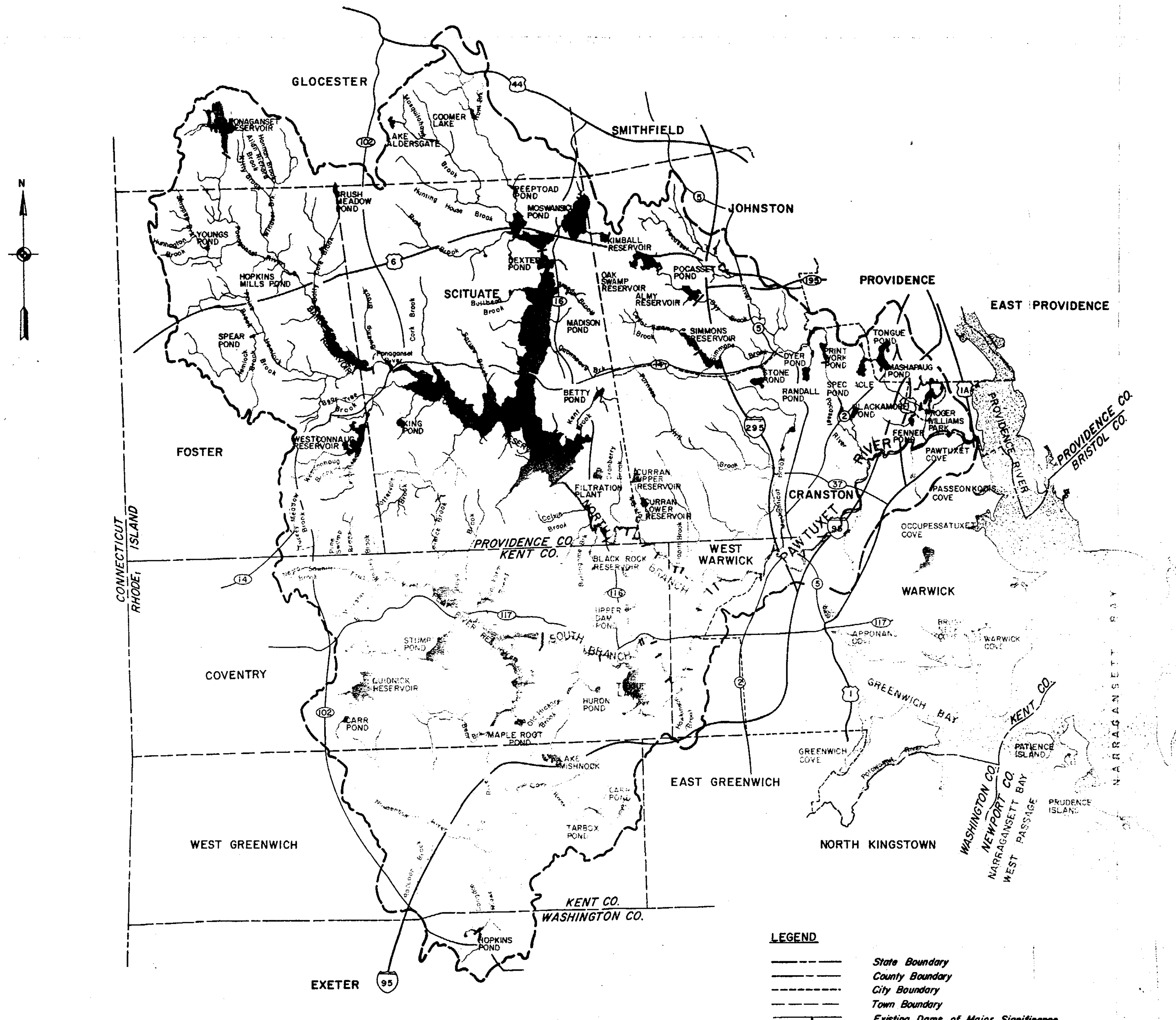
Annual charges are amortized over a 50-year period at the current interest rate of 7-7/8 percent.

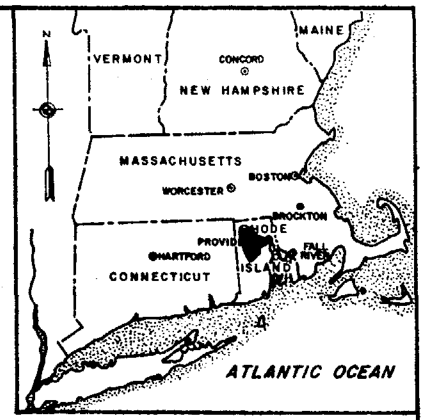
IX. CONCLUSIONS AND RECOMMENDATIONS

As mentioned earlier in this report, Federal participation in the construction of a small flood control project to protect the GE facility is not warranted because of the limited scope of the floodproofing project. However, technical assistance has been provided GE to aid in correcting the flooding problem. Representatives from GE are considering floodproofing, which appears to be the more affordable plan.

Incls
As stated

CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer





LOCATION MAP

SCALE IN MILES

0 10 20 30 40 50

SCALE IN MILES

LEGEND

State Boundary

County Boundary

City Boundary

Town Boundary

Existing Dams of Major Significance to the Study

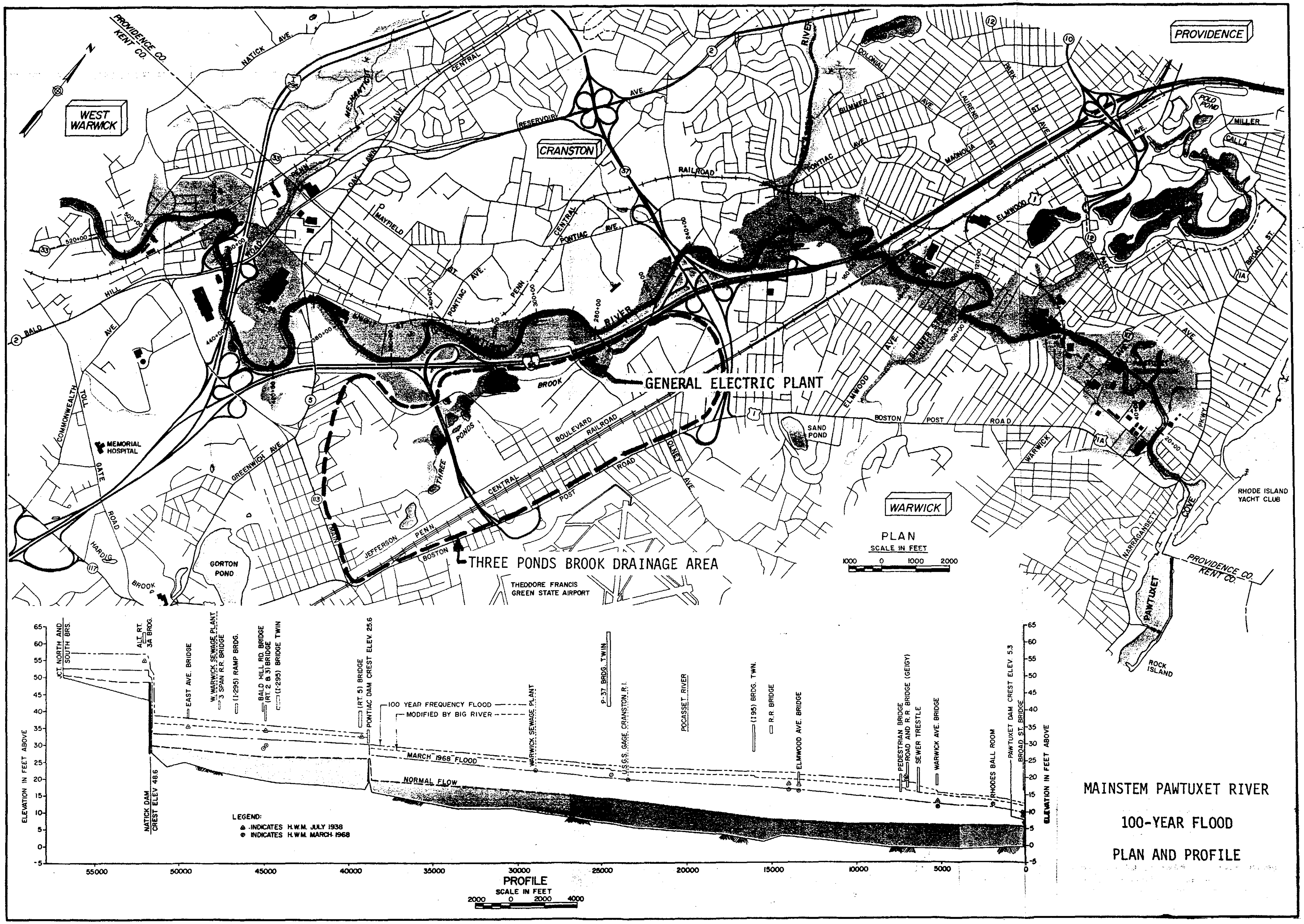
Watershed Limit

Selective Network of Major Highways Within the Watershed Area

BASIN MAP

MAINSTEM PAWTUXET RIVER

PLATE 1



MAINSTEM PAWTUXET RIVER

100-YEAR FLOOD

PLAN AND PROFILE

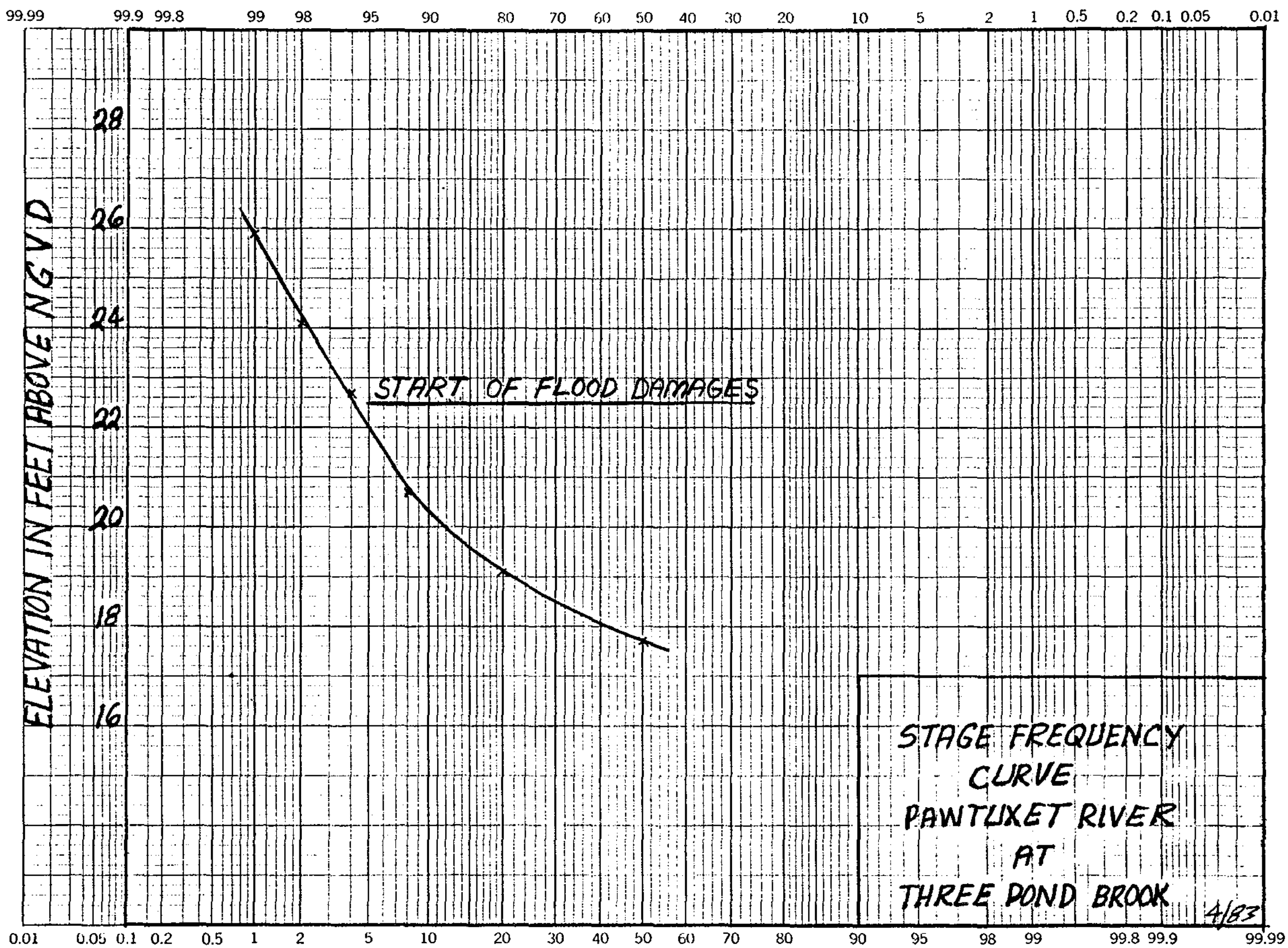
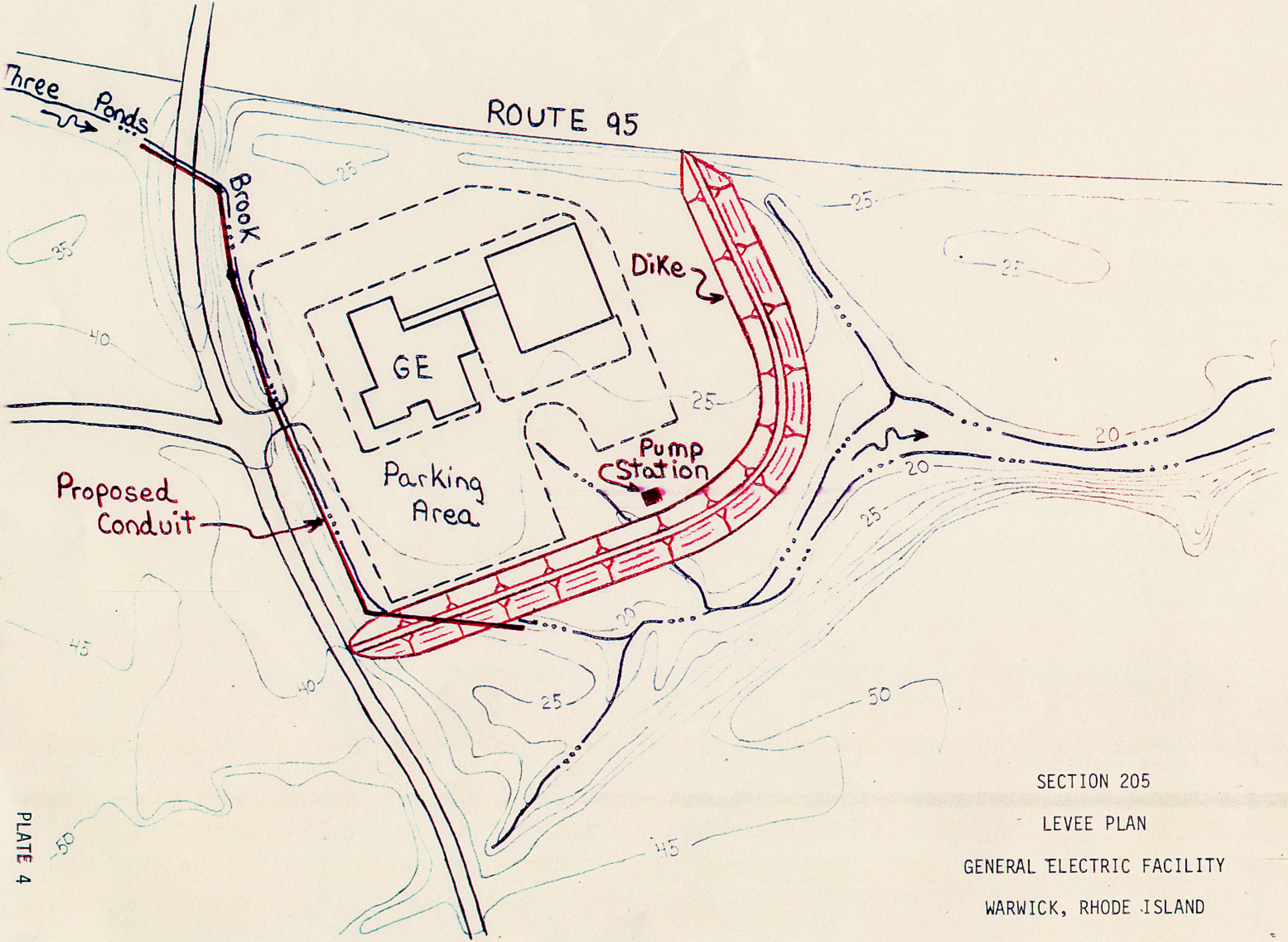

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
ELEVATION IN FEET ABOVE N.G.V.D.
28
26
24
22
20
18
16
START OF FLOOD DAMAGES
STAGE FREQUENCY
CURVE
PAWTUXET RIVER
AT
THREE POND BROOK
4/83
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

PLATE 3



SECTION 205

LEVEE PLAN

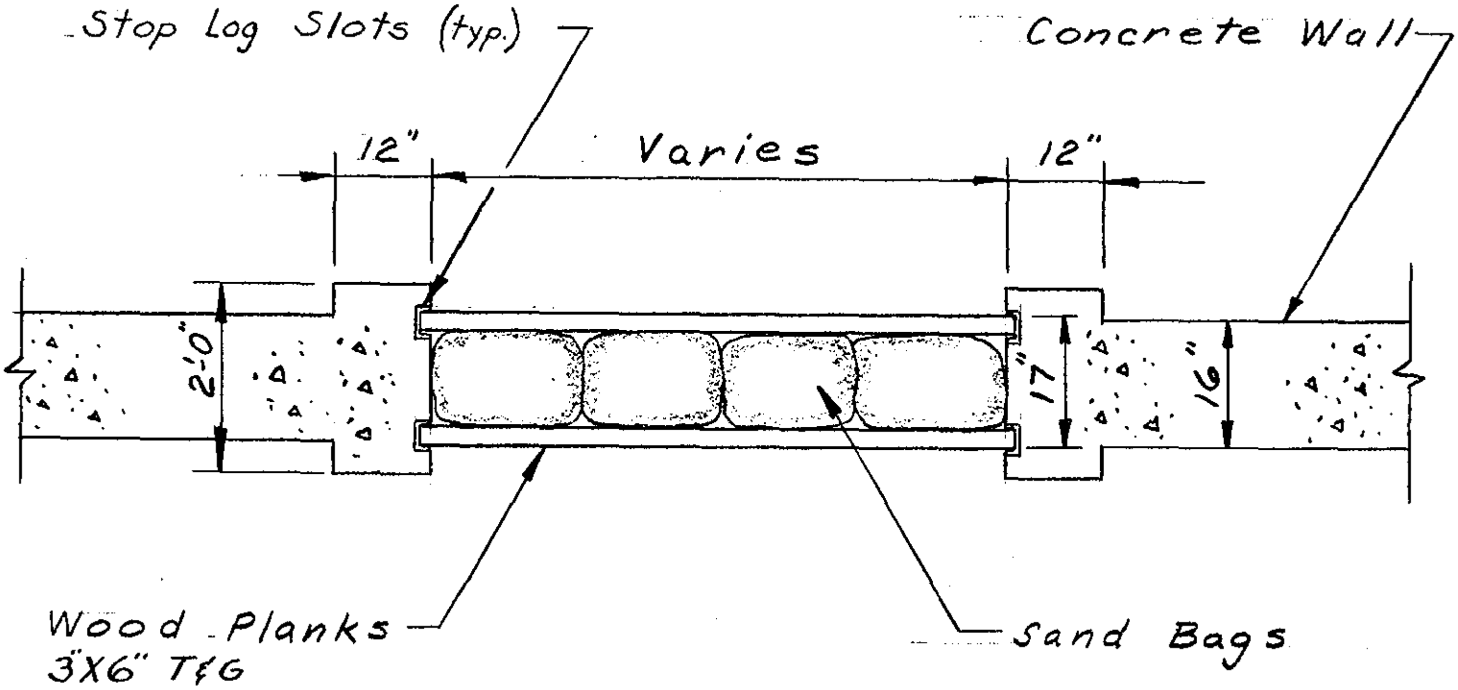
GENERAL ELECTRIC FACILITY

WARWICK, RHODE ISLAND

PLATE 4

ENTRANCE TO LOADING DOCK

TYPICAL ENTRANCE

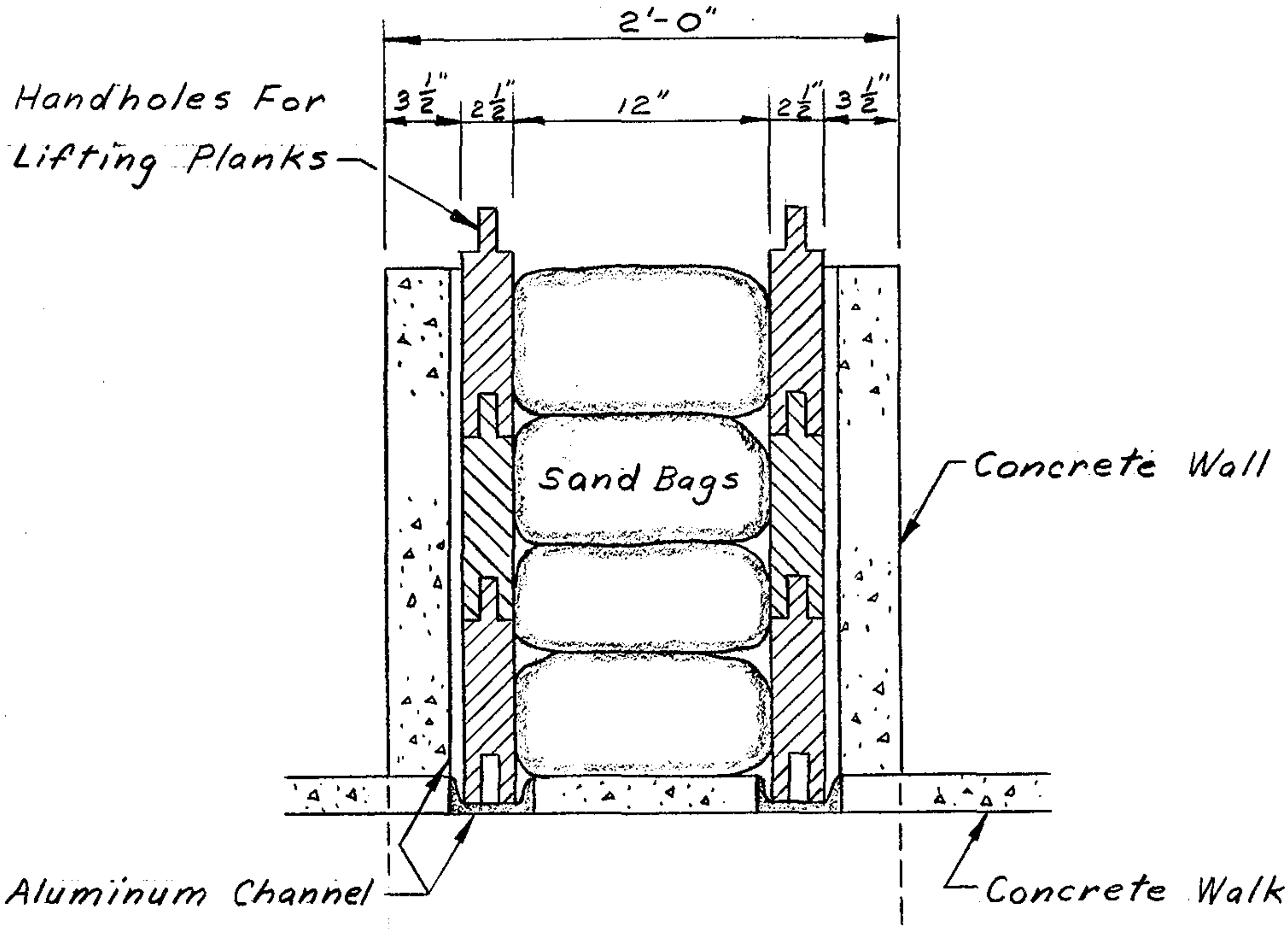


TYPICAL PLAN AT ENTRANCES

N.T.S.

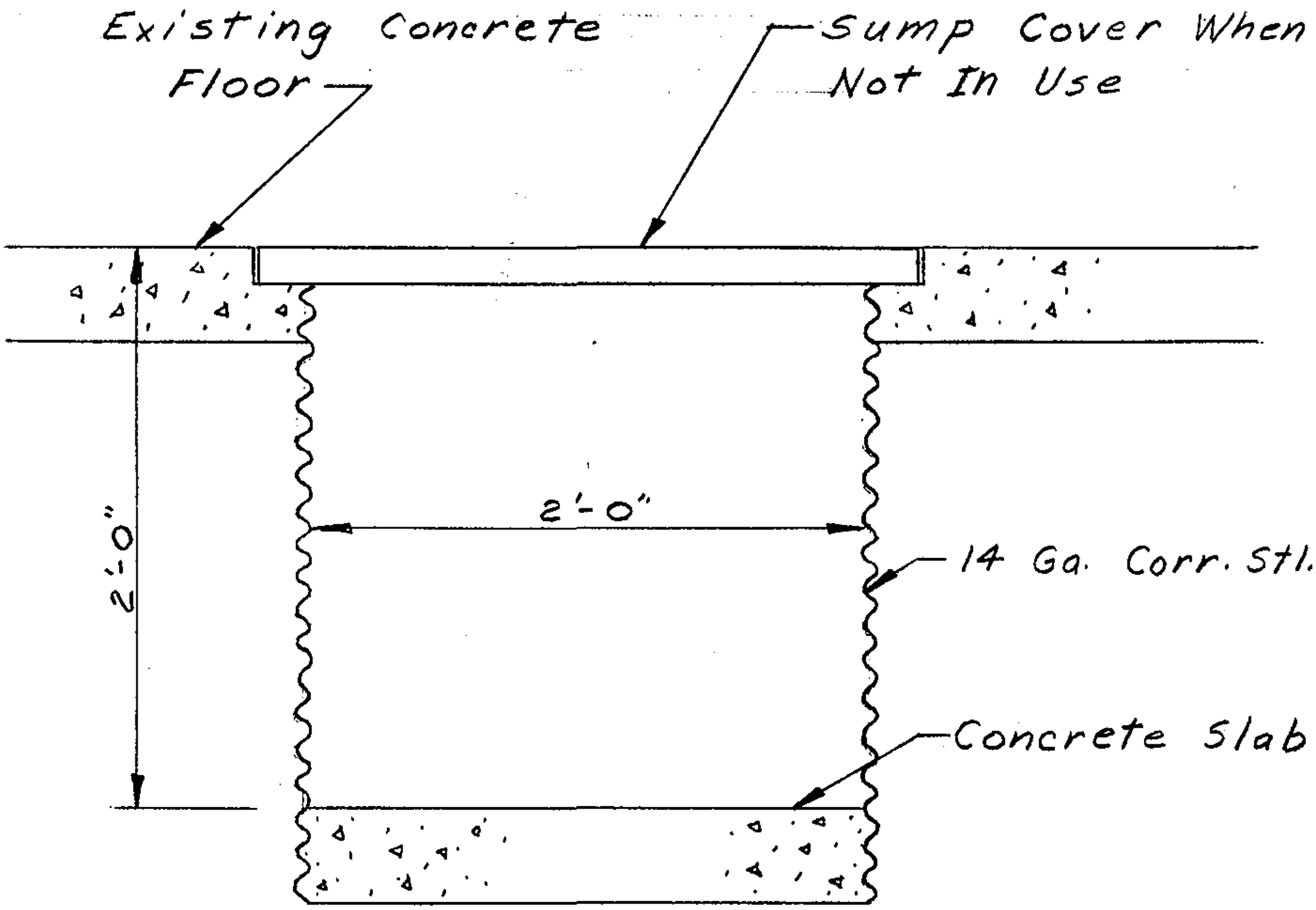
NOTES:

1. Depth of wall to be as required for soil conditions.
2. Water stops to be installed between new and existing walls.



SECTION THRU STOPLOG STRUCTURE

N.T.S.



SUMP PIT

N.T.S.

NOTE:

Sumps are designed for surface water only, not for relief of hydrostatic pressure below floor slab.